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# FACTORS AFFECTING THE QUALITY OF SOUTHERN SHORT CURE CHEDDAR CHEESE

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This bulletin contains the results of an investigation made to determine the factors which affect the quality of short cure cheddar cheese. Studies have been made concerning the effect of ripening temperature, amount of rennet extract used and manufacturing methods upon the quality of the ripened cheese by comparing the ripening temperatures of 45°, 60°, 70° and 80°F., by using 2, 4 and 8 ounces of rennet per 1000 pounds of milk and by comparing the quality of cheese manufactured by the cheddar, stirred curd and washed curd methods.

The temperature of ripening and the amount of rennet extract used were factors of most importance in the production of a high quality short cure cheese. The stirred curd and washed curd methods of manufacture were of little value in the production of a short cure cheese.

A high quality cheese was produced within a four weeks period. The best cheese produced within a four weeks period was ripened for two weeks at 45°F. and two weks at 60°Fahrenheit. The best cheese produced within an eight weeks period was ripened for two weeks at 45°F. and six weeks at 60°Fahrenheit. This cheese was slightly superior to the cheese ripened only four weeks. The use of 4 ounces of rennet per 1000 pounds of milk proved the most satisfactory of the various amounts of rennet used for the production of a short cure cheese. The cheddar method proved superior to either the stirred curd or washed curd methods of manufacture.

## CONTENTS

# FACTORS AFFECTING THE QUALITY OF SOUTHERN SHORT CURE CHEDDAR CHEESE

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Cheddar cheese has been made for many years, but no work was attempted to scientifically explain the ripening of cheese until fifty years ago. Since that time many investigators have studied ripening problems and much has been accomplished. Any study of cheese ripening is complicated by the many variable factors involved. Some of the first experimental work reported on the problem showed that a better flavor was developed when cheese was ripened at a temperature of about 40°F., and also that cheese could be held in storage a longer time with more desirable results at this temperature. In those days, bad flavors caused by coli-aerogenes and other undesirable bacteria were common, and no doubt the activities of these bacteria were reduced by the lower temperature. Hence, it was the common practice to ripen cheese for a long period of time at a low temperature in order to secure a high quality product. Many changes have taken place in the cheese industry since those early investigations. The use of bacterial starters, cleaner milk, pasteurization, improved cheese making equipment, and more sanitary methods, all have enabled the production of a better quality of cheese for the curing room.

Today the cheese factory operators and cheese dealers are not as much interested in being able to store cheese for a long period of time as they are in hastening the ripening, thereby decreasing the span of time between the production of the milk and the ultimate consumption of the cheese. This is especially true here in the South as the high cost of cold storage causes the dealer to shorten the ripening period; thus much of the cheddar or American cheese sold over the retail counter is not sufficiently ripened as indicated by lack of flavor and the presence of a firm rubbery body. Any modifications of the manufacturing and ripening methods which would produce a higher quality short cure cheese would therefore be highly desirable.

## REVIEW OF LITERATURE

A review of the literature reveals that there are many factors that influence the ripening of cheese. Some of these factors which can be controlled by the cheesemaker include the amount of rennet or other enzymes present, amount of salt, acidity of cheese, moisture content of cheese, curd treatment, and ripening temperature.

**Enzymes.** The importance of rennet in the ripening of cheese is not well established. Babcock and co-workers (4) quoted that quantities of rennet increased protein decomposition, stating that this was probably due to the presence of pepsin in the extract. Doane (6) and Sammis (16) working independently stated that using a larger amount of rennet extract caused cheese to ripen faster. Sherwood (17) maintained that different lots of

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pepsin or rennin may possess different proteolytic powers. Harding (10) stated that the action of rennet enzymes extend only to the production of peptones. Freeman (8) found that additional amounts of pure rennin increased the rate of proteolysis in cheddar cheese ripening, increased slightly the rate at which the flavor developed, and produced an aged product with a slightly higher flavor score. He also found that added pepsin increased the rate of proteolysis during cheddar cheese ripening, particularly at the beginning of the ripening period and at the lower ripening temperature; however, it did not accelerate the development of flavor, but produced an aged product with appreciably higher flavor score.

**Salt.** Marquardt (11) studied the relationship of salt content to the quality of cheddar cheese and stated that the addition of 1½ to 3 per cent salt did not affect the body of the cheese, but cheese to which 3 per cent salt was added scored one point lower on flavor than the cheese to which 1½ and 2¼ per cent of salt was added. He also states that these results are in close agreement with those previously reported by Riddet (15).

**Acidity.** Haglund, et al. (9) and Townsend (19) found that increasing the acidity of the milk at coagulation time increased the formation of water soluble nitrogenous compounds during ripening. Price (14) found that there was a correlation between high acidity and bitter flavor in cheese. Phillips (13) has shown that a high acid cheese ripens slower than one with low acidity. Freeman (8) states that low initial acidity was conducive to more rapid proteolysis but had no effect on the rate of flavor development, and also that flavor was slightly inferior in low acid cheese. Doane, Aderhold and Wilson (7) suggested in an article discussing acidity development in the manufacture of cheddar cheese, that cheese made with low acidity development and good milk can be ripened at higher than usual temperatures with a favorable effect upon the quality of the finished product.

**Moisture Content.** Van Slyke and Hart (20) found that a higher water content of cheese was conducive to a more complete proteolysis. Sammis (16) claimed that it was desirable to incorporate more moisture in producing a quick curing cheese.

**Curd Treatment.** Marquardt (11) in comparing cheddar and granular type cheeses states that cheddaring the curd improved the score 2.4 points over the lowest scoring granular type cheese and 0.3 point over the best granular type cheese. He observed that variation in cooking temperature between 96° and 108°F. did not materially affect the quality of the cheese, but there was a definite moisture decrease with an increase in cooking temperature. Also curd salting produced better cheese than brine salting or rubbing.

**Ripening Temperature.** Smith (18) and Van Slyke, Smith and Hart (22) in early investigations found that lower ripening temperatures resulted in a cheese of high score value. Van Slyke and Hart (20) state that between 32° and 72°F. each one degree increase in temperature resulted in 0.5 per cent increase in soluble nitrogen, the greater portion of the increase being in the form of amino acids and ammonia. Atkinson (3) observed that a ripening temperature between 40° and 60°F. was best for producing a cheese of good flavor. Wojtkiewicz and Inikkoff (23) concluded that the use of higher ripening temperatures for producing quick ripened cheese is

of limited value. Freeman (8) compared ripening temperatures of 45° and 63°F. and found that proteolysis in cheddar cheese ripening can be increased 40 to 100 per cent by raising the ripening temperature from 45° to 63°Fahrenheit. The maximum score was reached more quickly when cheese was ripened at 63°F., and the cheese ripened at this temperature attained a higher maximum score. However, he stated that the higher ripening temperature favored the occurrence of bitter flavor. Van Slyke and Price (21) cited the technics used by Allen (2) and Bartel, Sandberg and Haglund (5) as being reliable means of determining ripening, and Allen (2) stated that the method, used by many workers in the past, of determining the amount of soluble nitrogen present at different intervals of ripening, merely gave an estimate of the total nitrogen but no information of the different types of nitrogen. Bartel, Sandberg, and Haglund (5) described a method of securing a uniform sample for analysis in studying the ripening of cheese, and state that rennet and bacterial action are the two most important factors influencing the rate of ripening.

The effect of many factors upon the ripening of cheese seems to be fairly well established. Nevertheless, there is no complete theory of ripening that is universally accepted today, and there is need for detailed information concerning the effect of various ripening treatments upon the quality of the finished product and the proteolysis that takes place during the ripening process in the production of a short cure cheese.

## PROCEDURE

This investigation was conducted by the Texas Agricultural Experiment Station in cooperation with the Department of Dairy Husbandry. A preliminary investigation was conducted to determine the important factors influencing the quality of short cure cheese. Those factors, which proved to be important in influencing the quality of cheese, were then studied in more detail by making a number of lots of cheese using different methods of manufacture. The cheese was ripened by various treatments. Flavor, body and texture, ripening observations and chemical analyses of the different lots of cheese were recorded at intervals during the ripening period.

### Manufacturing Methods

Unless otherwise stated the cheese used in this investigation was made from pasteurized milk that tested approximately 3.7 per cent butterfat. Two per cent starter was used, and the milk was set at 86°F. using three and one-half ounces of rennet per 1000 pounds of milk. The curd was cut with one-half inch curd knives and was cooked at 98° to 102°Fahrenheit. The acidity of the whey at dipping time was .15 per cent, and the curd was milled when the acidity had developed to .5 per cent. Salt was added at the rate of two and one-half pounds per 1000 pounds of milk. The cheese was pressed into hoops and was later sealed into ten ounce valve vented cans for ripening. This type can was used because it provided a means of controlling surface mold growth and also a convenient portion of cheese for ripening and scoring. Figure 1. shows the type of hoop and the valve vented can used in this investigation.

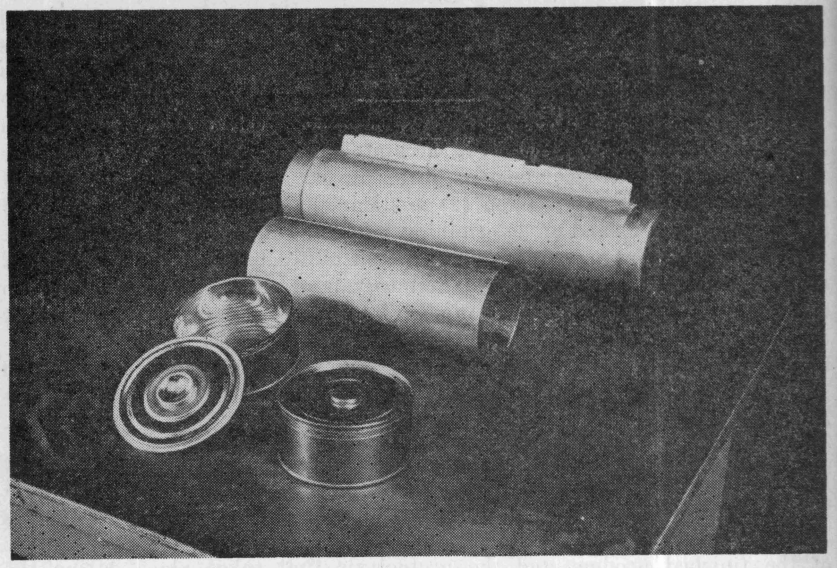

Figure 1. The Cheese Hoop and Valve Vented Can Used.

## Methods of Grading and Analysis

The score value of the cheese was determined by the U.S.D.A. cheese score card which gives flavor 30, body and texture 40, make up 20, color 10, total 100 for maximum scores. In this investigation only the flavor and the body and texture scores were determined. The make up of all lots of the cheese was the same since ten ounce portions of the cheese were sealed in the valve vented cans for ripening. A study was not made of the color score values as the color was similar for the cheese within each series. In cases where a total score is given, the make up and color were considered perfect.

The following general classification was used to rank and describe the flavor and the body and texture in determining a high quality cheese: for flavor, perfect 30, excellent 25 or above, good 24 to 25, acceptable 23 to 24, and inferior less than 23; for body and texture, perfect 40, excellent 39 or above, good 37 to 39, acceptable 36 to 37 and inferior less than 36. The degree of ripeness was not determined solely from flavor and body scores given, but also included the observations of the judges as to their opinion of the ripening qualities of the cheese. The score values presented represent the average scores given by three experienced judges. The number of samples of cheese examined by the judges varied with the different series, but ranged from three to thirteen samples. As a measure of the rate of ripening, chemical analyses were made to determine the amount of various protein fractions present at intervals during the ripening process.

The moisture content was determined by drying a two to three gram sample of cheese for 24 hours at 100°C. plus two hours at a vacuum of 20 to 25 inches.

The pH of the cheese was determined by the use of a Coleman potentiometer.

The fat content of the milk and cheese was determined by the Babcock method.

The firmness of the cheese was found by the use of a penetrometer developed by this laboratory. The hardness of the cheese was measured by recording the weight of mercury required to press a plunger into the cheese displacing approximately .2 cc. volume. The plunger was 4 mm. in diameter and was depressed 14.7 millimeters. The plunger operated in a pipe sleeve that was 11 cm. long. A small platform was mounted on the upper end of the plunger on which a beaker was placed to collect the mercury. The mercury was allowed to flow from a separatory funnel through a glass tip. The opening in the tip was such that the rate of flow was 600 grams per minute. These parts were mounted on a ring stand. Ten ounce samples were tempered at 60°F. for 24 hours or more before determining the hardness. An average of five determinations on each sample was taken to represent the hardness value. Figure 2. shows the penetrometer used.

The analyses made to establish the rate of ripening included the total nitrogen content of the cheese, the water soluble nitrogen which represents the per cent of the total nitrogen present in water suspension under the stated conditions, the water soluble nitrogen not precipitated by trichloracetic acid which indicates the non-protein nitrogen present, the water soluble nitrogen not precipitated by tannic acid-salt solution and the water soluble nitrogen not precipitated by phosphotungstic acid which are somewhat similar in their indication of the per cent amino nitrogen, but differ in the kind of amino acids they separate. Although the tannic acid-salt and the phosphotungstic acid methods are similar in their indications, both methods were used in this investigation as there is some question as to which is most valuable in determining cheese ripening.

In the tables the total nitrogen is expressed as percentage of the weight of the cheese and the fractions as the percentages of the total nitrogen.

Total nitrogen was determined in a one gram sample of cheese by the Kjeldahl-Gunning-Arnold method (1).

The nitrogen fractions were determined by a micro-Kjeldahl method. The different nitrogen fractions were prepared as follows: A water soluble nitrogen solution of the cheese was obtained by mixing 10 gm. of cheese and 96 ml. of water and agitating with a stirring device at about 5000 r.p.m. for five minutes at room temperature. The solution was then digested in a water bath at 50° to 55°C. for one hour after which the solution present below the fat layer was removed with a pipette and filtered through a diatomaceous filter to obtain a clear filtrate. The water soluble nitrogen was found by using 1 to 3 ml. of this filtrate for the nitrogen determination.

The water soluble nitrogen not precipitated by trichloracetic acid was determined by placing 10 ml. of the water soluble nitrogen filtrate in a test tube and adding 10 ml. of a solution containing 2 parts of a 20 per cent trichloracetic acid solution and 8 parts of water. The test tube was stoppered, and the contents were mixed. On the following day, the solution was filtered, and 2 or 3 ml. of the filtrate were used for the nitrogen determination.

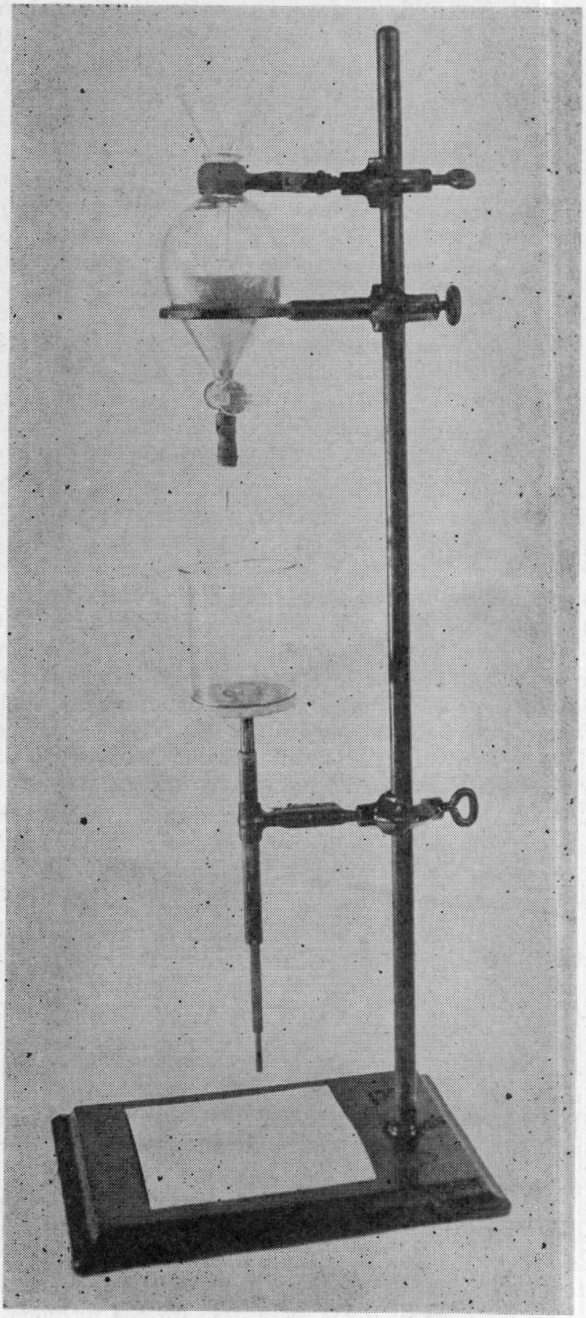

**Figure 2. Penetrometer Used to Determine Hardness of the Cheese.**

The water soluble nitrogen not precipitated by tannic acid-salt solution was secured by mixing 5 ml. of the water soluble nitrogen filtrate and 12½ ml. of 30 per cent sodium chloride solution. The mixture was cooled to 12°C., and 7½ ml. of 24 per cent tannic acid solution were added. On the following day the solution was filtered, and 2 ml. of the filtrate were used for nitrogen analysis.

The water soluble nitrogen not precipitated by phosphotungstic acid was determined by placing 5 ml. of the water soluble nitrogen filtrate in a test tube and adding 5 ml. of a mixture consisting of 2 parts of a 10 per cent phosphotungstic acid solution and 3 parts of 25 per cent sulfuric acid. The test tube was stoppered, and the contents mixed. On the following day, the solution was filtered, and 3 ml. of the filtrate were used for the nitrogen determination.

The nitrogen content of the various fractions was found by measuring the filtrate of the different fractions into 30 ml. Kjeldahl flasks. Then 1½ to 2½ ml. of concentrated sulfuric acid and 1½ to 2 gm. of Gunning-Arnold catalyst (1) (15 parts $K_2SO_4$ and .7 parts HgO) were added, and the contents were digested for 30 minutes on a six place heater. After the digestion period, the flasks were air cooled, and 3 ml. of 8 per cent sodium thiosulfate solution were added. The flasks were placed in an ice water bath, and 6 to 7 ml. of 30 per cent sodium hydroxide solution were added. The ammonia was distilled by steam distillation and collected in 20 ml. of boric acid solution consisting of one part of a stock boric acid solution and six parts of water. The stock solution of boric acid was made according to the procedure of Menefee and Overman (12). Five drops of an indicator solution were added; this indicator consisted of 100 mg. of methyl red and 30 mg. of methylene blue dissolved in 60 ml. of 95 per cent ethyl alcohol and made up to 100 ml. with distilled water. The ammonia was titrated with .01 normal sulfuric acid.

Figure 3. shows the apparatus designed and used for the steam distillation of the ammonia in the digested sample. The apparatus consisted of three units; namely, (1) the steam generator, (2) the distilling head and (3) the condenser. The units were assembled by the use of rubber. A plain two-hole stopper was used in the neck of the steam generator, a modified stopper connected the digestion flask to the distilling head, and a rubber tube connected the distilling head to the condenser. A piece of rubber tubing was used on the steam lead to allow the removal and replacing of the digestion flask without breakage. The apparatus eliminated the difficulties of sucking back and the necessity of rinsing the digested sample from the digestion flask into the distilling apparatus. It also has the advantage of being more rapid than similar apparatus suggested in the literature, and at the same time does not sacrifice accuracy.

## Preliminary Investigation

Preliminary work was done in 1936 and 1937 to obtain information concerning the effect of variations in the manufacturing methods upon the quality of short cure cheese.

**Rennet.** In a series consisting of seven paired lots of cheese made from pasteurized milk, the effect of nine ounces of rennet extract per 1000

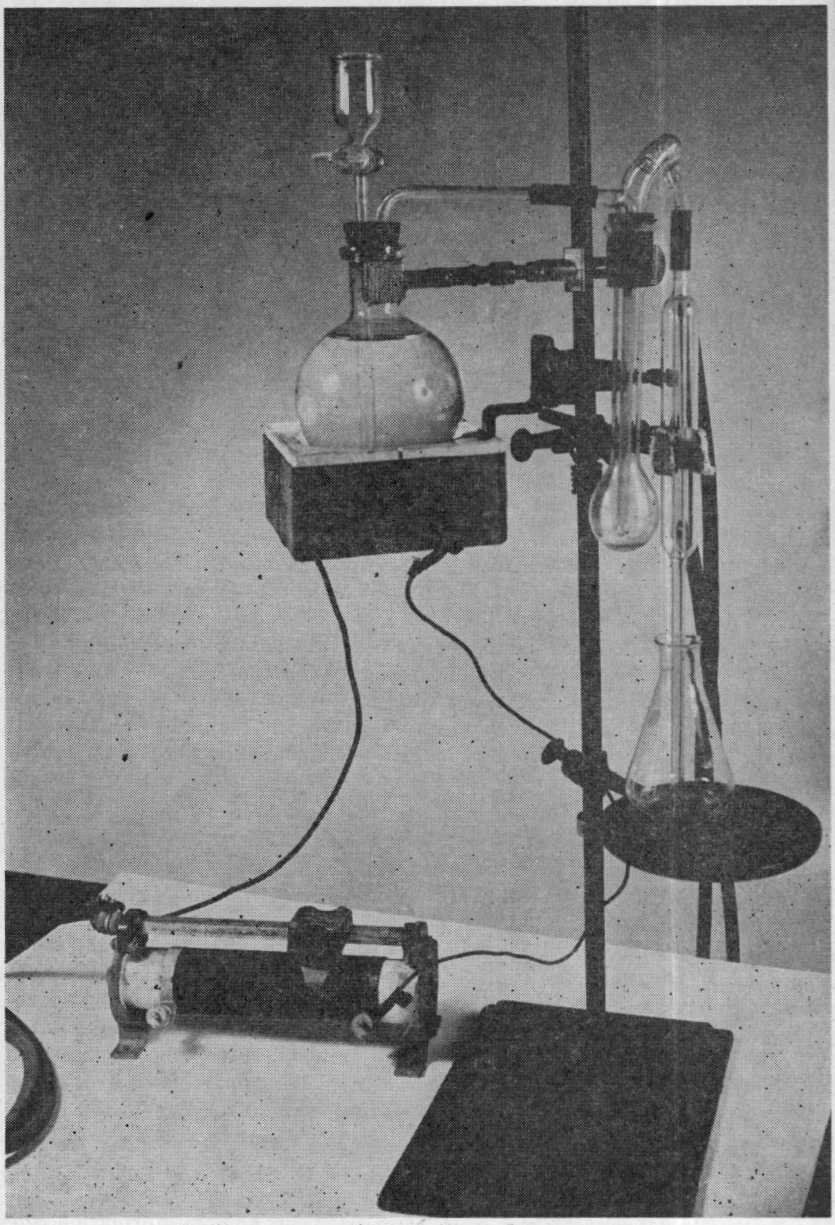

**Figure 3. The Micro-Kjeldahl Distilling Apparatus.**

pounds of milk was compared to the control in which three ounces of rennet were used per 1000 pounds of milk. Comparisons were made after the cheese was ripened for 11 weeks at 50°Fahrenheit. The results, as given in Table 1, show that after eleven weeks of ripening at 50°F. the control lots of cheese were of higher quality than the lots of cheese containing nine ounces of rennet. Two defects, a bitter flavor and a sticky body, appeared frequently in the experimental lots containing the additional amount of rennet. The occurrence of the sticky body indicated that the rennet extract was effective in breaking down the body. The bitter flavor was a more serious defect and indicated the use of excess rennet.

**Table 1. The effect of rennet extract upon the quality, pH and moisture content of cheese ripened at 50°F. for 11 weeks**

| Characteristic | Rennet extract per 1000 lbs. of milk | |
|---|---|---|
| | 3 oz. | 9 oz. |
| Flavor score | 24.12 (acceptable) | 23.62 (acceptable) |
| Body and texture score | 36.88 (acceptable) | 36.56 (acceptable) |
| pH — 3rd day | 5.05 | 5.11 |
| pH — 5th week | 5.04 | 5.11 |
| Moisture per cent — 1st day | 36.16 | 36.76 |
| Number of samples | 7 | 7 |

**Salt.** A series of three trials was used to study the effect of the amount of salt on the ripening qualities of cheese. One portion of curd was salted at the rate of two pounds per 1000 pounds of milk, and another was salted at the rate of 3½ pounds per 1000 pounds of milk. The cheese was examined for quality after a ripening period of ten weeks at 50°Fahrenheit. The results of the study to determine the effect of the amount of salt upon the quality of cheese showed that at the end of a 10 weeks ripening period the lots containing 2 pounds of salt per 1000 pounds of milk were flat in flavor; whereas, the lots having 3½ pounds of salt per 1000 pounds of milk were salty in flavor and hard in body. This indicates that the range in the amount of salt that can be added to cheese without injuring the quality is quite narrow.

**Method of Manufacture.** To compare the ripening qualities of Colby or stirred curd type cheese with the cheddar type, six lots of stirred curd and six lots of cheddar cheese were made and ripened at 50°F. for 10 weeks. Table 2 shows a comparison of the ripening qualities of stirred curd type and cheddar type cheese. The stirred curd cheese was better in flavor but slightly inferior in body. It was slightly acid in flavor; whereas, the cheddar type cheese had a flat flavor. The body of the stirred curd cheese was short and that of the cheddar cheese was softer and smoother. The stirred curd cheese was slightly inferior to the cheddar type cheese; however, a further study of this phase of the work seemed advisable as the stirred curd type cheese was superior in flavor development.

**Table 2. The effect of two methods of manufacture upon the quality, pH and moisture content of cheese ripened at 50°F. for 10 weeks**

| Characteristics | Cheddar Method | Stirred Curd Method |
|---|---|---|
| Flavor score | 23.87 (acceptable) | 24.37 (good) |
| Body and texture score | 37.66 (good) | 37.08 (good) |
| pH — 3rd day | 5.09 | 5.05 |
| pH — 7th week | 5.22 | 5.10 |
| Moisture per cent — 1st day | 38.41 | 38.46 |
| Number of samples | 6 | 6 |

**Ripening Temperature.** The effect of ripening temperature upon the quality of Colby cheese was studied in a series of three trials. Half of the cheese in each trial was ripened at 70°F., and the other half was ripened at 50°F. for a period of 7 weeks. The effect of ripening temperature upon the quality of Colby cheese is shown in Table 3. The average flavor score of the cheese held at 70°F. was described as being medium full and was better than that of the cheese held at 50°Fahrenheit. Although the cheese held at the higher temperature was crumbly and inferior in body, it rated the same total score as did the control. There was a considerable loss in moisture during the ripening period in the cheese ripened at 70°F., but this loss did not occur in cheese ripened at 50°Fahrenheit.

**Table 3. The influence of ripening temperature upon the quality, pH and moisture of Colby cheese ripened for 7 weeks**

| Characteristics | Ripening Temperature | |
|---|---|---|
| | 50°F. | 70°F. |
| Flavor score | 23.83 (acceptable) | 24.17 (good) |
| Body and texture score | 35.34 (inferior) | 35.00 (inferior) |
| pH — 3rd day | 5.07 | 5.07 |
| pH — 7th week | 5.09 | — |
| Moisture per cent — 1st day | 37.84 | 37.84 |
| Moisture per cent — 7th week | 38.09 | 34.84 |
| Number of samples | 3 | 3 |

**Curd Treatment.** In another series the effect of ripening washed curd cheese at different temperatures was studied by washing one-half of the curd in each of ten lots; whereas, the other half was not washed and was used as a control. One-half of the washed curd cheese and one-half of the control were ripened at 70°F. while the other portions were ripened at 50°Fahrenheit. The results showing a comparison of the effect of washed and unwashed curd cheese ripened at different temperatures upon the quality of cheese are presented in Table 4. The washed curd cheese was superior

to the control in the flavor and body scores. The washed curd lots ripened at 70°F. were slightly better in flavor than the washed curd lots ripened at 50°F.; however, the reverse was true in regard to body. The control lots of cheese that were ripened at 70°F. were lower in quality than the control lots ripened at 50°Fahrenheit. The washed curd cheese which was ripened at the lower temperature was criticized for being flat in flavor; whereas, the unwashed curd cheese that was ripened at the higher temperature had a slight acid flavor.

**Table 4. A comparison of the ripening qualities of unwashed and washed curd cheese at different temperatures**

| Characteristics | Control | | Washed Curd | |
|---|---|---|---|---|
| | Ripening temperature | | Ripening temperature | |
| | 50°F. | 70°F. | 50°F. | 70°F. |
| Flavor score | 24.07 (good) | 23.70 (acceptable) | 24.17 (good) | 24.50 (good) |
| Body and texture score | 36.34 (acceptable) | 35.68 (inferior) | 37.00 (good) | 36.38 (acceptable) |
| pH — 3rd day | 5.08 | 5.08 | 5.10 | 5.10 |
| pH — 7th week | 5.09 | 5.13 | 5.26 | 5.31 |
| Moisture per cent—1st day | 38.05 | 38.05 | 39.79 | 39.79 |
| Moisture per cent—7th week | 37.49 | 36.82 | 39.43 | 38.16 |
| Number of samples | 10 | 10 | 10 | 10 |

## Effect of Temperature Upon Ripening

After the preliminary investigation was completed, a more comprehensive study was conducted to determine the effect of temperature upon the ripening of cheese. Thirteen different lots of cheese were ripened at temperatures of 45°, 60°, 70° and 80°F. for various time intervals. The curing program was carried out by placing one lot of cheese at each of the temperatures. Three other lots of cheese were held at 45°F. for 2 weeks, and then one lot was held at each of the temperatures of 60°, 70° and 80°F. for six weeks.

Three more lots were held at 45°F. for 4 weeks, and then one lot was held at each of the other temperatures studied for 4 weeks. At the end of eight weeks all lots were returned to the 45°F. temperature for another period of eight weeks to determine if ripening could be checked successfully.

Another lot of cheese was ripened at each of the above temperatures for 16 weeks, and still another lot was held at each of the ripening temperatures of 60°, 70° and 80°F. for 8 weeks, and then held at 45°F for another 8 weeks. The above described procedure gave information upon 34 different ripening combinations.

## Effect of the Amount of Rennet Extract Upon Ripening of Cheese at Various Temperatures

In order to determine the effect of the amount of rennet extract upon the quality of cheese ripened at different temperatures, three experimental

lots of cheese were prepared by using 2, 4 and 8 ounces of rennet extract per 1000 pounds of milk. The moisture content was controlled such that the percentage moisture in all the lots of the finished cheese was practically the same. The cheese was paraffined and ripened at the temperatures of 45°, 60°, 70° and 80°F. for 12 weeks. Flavor, body and texture, ripening observations and protein hydrolysis determinations were made at the end of the ripening period.

### Effect of Stirred Curd and Cheddar Methods of Manufacture Upon the Rate of Ripening

A comparison of the effect of the stirred curd and cheddar methods of manufacture upon the rate of ripening was made by preparing two experimental lots of cheese from identical milk. One lot was made by the cheddar method and the other by the stirred curd method. The cheese was sealed in cans and ripened at 45°, 60°, 70° and 80°Fahrenheit. Flavor, body and texture, and ripening observations were made when the cheese had cured 8 weeks and again at 16 weeks.

### Effect of High Acidity and Washing Treatment of the Curd Upon Rate of Ripening

To determine the effect of high acidity and washing treatments of the curd upon the rate of ripening of cheese, three lots of milk were made into cheese. In each lot one-half of the milk was ripened in order to make a cheese with an acidity of pH 5.0, and the other half of the milk was made such that the acidity of the cheese was pH 5.5. After the curds were milled, each was divided into three portions. One portion was washed with cold water (50°F.) for 15 minutes, thereby lowering the temperature of the curd to 67°Fahrenheit. The second portion was pasteurized with hot water for 30 minutes at the temperature of 145° to 150°F. and then cooled to 90°Fahrenheit. The third lot was not treated and was used as a control. Flavor, body and texture and ripening observations were made at the end of a 4 weeks period.

## RESULTS

Of the several treatments used in the preliminary investigation, variations in the ripening temperature seemed most effective in influencing the quality of short cure cheese. Large amounts of rennet and washing the curd encouraged the breakdown of the body, but they were not effective in the development of flavor. The results of a more detailed study of these factors are shown.

### Effect of Various Ripening Temperatures Upon the Rate of Ripening

The 13 lots of cheese used in this investigation were divided into six experimental groups to determine the effect of various treatments upon the quality and rate of ripening.

#### Experimental Groups

Group I —Ripened at 45°, 60°, 70° or 80°F. for periods of 2, 4, 8 or 16 weeks.

Group II —Ripened at 45°F. for 2 weeks plus 2 or 6 weeks periods at 60°, 70° or 80°F.

Group III—Ripened at 45°F. for 4 weeks plus 4 weeks at 60°, 70° or 80°F.

Group IV—Ripened at 45°F. for 2 weeks plus 6 weeks at 60°, 70° or 80°F. plus 8 weeks at 45°F.

Group V —Ripened at 45°F. for 4 weeks plus 4 weeks at 60°, 70° or 80°F. plus 8 weeks at 45°F.

Group VI—Ripened at 60°, 70° or 80°F. for 8 weeks plus 8 weeks at 45°F.

The effect of ripening temperatures upon the pH value, moisture content and the firmness of body of the different lots of cheese used in this investigation is shown in Table 5.

**Table 5. The effect of various ripening treatments upon the pH, moisture content and firmness of the ripened cheese**

| Ripening Treatment | pH | Moisture Per Cent | Hardness Grams |
|---|---|---|---|
| 1 day of age | 5.32 | 37.4 | — |
| **Group I** | | | |
| 2 wks. at 45°F. | 5.27 | 37.8 | 553 |
| 4 wks. at 45°F. | 5.30 | 37.4 | 568 |
| 8 wks. at 45°F. | 5.34 | 37.2 | 571 |
| 16 wks. at 45°F. | 5.57 | 36.7 | 474* |
| 2 wks. at 60°F. | 5.24 | 37.5 | 563 |
| 4 wks. at 60°F. | 5.32 | 37.4 | 589 |
| 8 wks. at 60°F. | 5.28 | 37.4 | 582 |
| 16 wks. at 60°F. | 5.64 | 36.5 | 592 |
| 2 wks. at 70°F. | 5.22 | 37.4 | 559 |
| 4 wks. at 70°F. | 5.28 | 37.1 | 581 |
| 8 wks. at 70°F. | 5.35 | 36.3 | 586 |
| 16 wks. at 70°F. | 5.75 | 36.5 | 649 |
| 2 wks. at 80°F. | 5.21 | 37.2 | 621 |
| 4 wks. at 80°F. | 5.32 | 37.2 | 705 |
| 8 wks. at 80°F. | 5.39 | 36.4 | 729 |
| 16 wks. at 80°F. | 5.58 | 36.2 | 702 |
| **Group II** | | | |
| 2 wks. at 45°F. plus 2 wks. at 60°F. | 5.25 | 37.3 | 549 |
| 2 wks. at 45°F. plus 2 wks. at 70°F. | 5.25 | 37.4 | 529 |
| 2 wks. at 45°F. plus 2 wks. at 80°F. | 5.27 | 37.2 | 590 |
| 2 wks. at 45°F. plus 6 wks. at 60°F. | 5.30 | 36.8 | 546 |
| 2 wks. at 45°F. plus 6 wks. at 70°F. | 5.32 | 36.9 | 557 |
| 2 wks. at 45°F. plus 6 wks. at 80°F. | 5.41 | 36.6 | 672 |
| **Group III** | | | |
| 4 wks. at 45°F. plus 4 wks. at 60°F. | 5.29 | 38.1 | 524 |
| 4 wks. at 45°F. plus 4 wks. at 70°F. | 5.28 | 37.0 | 526 |
| 4 wks. at 45°F. plus 4 wks. at 80°F. | 5.30 | 37.1 | 569 |
| **Group IV** | | | |
| 2 wks. at 45°F. plus 6 wks. at 60°F. plus 8 wks. at 45°F. | 5.67 | 37.5 | 515 |
| 2 wks. at 45°F. plus 6 wks. at 70°F. plus 8 wks. at 45°F. | 5.61 | 37.3 | 552* |
| 2 wks. at 45°F. plus 6 wks. at 80°F. plus 8 wks. at 45°F. | 5.65 | 37.5 | 596 |
| **Group V** | | | |
| 4 wks. at 45°F. plus 4 wks. at 60°F. plus 8 wks. at 45°F. | 5.62 | 37.2 | 483 |
| 4 wks. at 45°F. plus 4 wks. at 70°F. plus 8 wks. at 45°F. | 5.59 | 37.0 | 499 |
| 4 wks. at 45°F. plus 4 wks. at 80°F. plus 8 wks. at 45°F. | 5.51 | 37.9 | 567 |
| **Group VI** | | | |
| 8 wks. at 60°F. plus 8 wks. at 45°F. | 5.72 | 37.1 | 513* |
| 8 wks. at 70°F. plus 8 wks. at 45°F. | 5.85 | 37.3 | 562 |
| 8 wks. at 80°F. plus 8 wks. at 45°F. | 5.57 | 36.9 | 684 |

*Outstandingly desirable body.

The pH of the cheese increased slightly with age, but the temperature of curing appeared to have no appreciable effect upon the rate of change. The decrease in moisture due to the increase in ripening temperature was so slight it is doubtful that it affected the quality of the cheese or rate of curing.

The body of the cheese increased in firmness with the higher ripening temperature. It also increased as the time of curing increased except for the lots of cheese ripened at 45°F. for 16 weeks.

A comparison of the hardness values with the body scores indicated that a value of approximately 525 grams was associated with the most desirable body. A relationship between the hardness value and the body score did not exist in all cases; however, cheese with hardness values considerably higher than 525 grams received low body scores. Cheese with a hardness value as high as 700 grams usually had a rubbery, dry or crumbly body, and cheese with a hardness value of less than 400 grams could be expected to have a soft pasty body.

The detail scores and ripening observations of the various lots of cheese are presented in Table 6.

**Table 6. The effect of various ripening treatments upon the quality of ripened cheese**

| Ripening Treatment | Total Score | Flavor Score | Body and Texture Score | Degree of Ripeness |
|---|---|---|---|---|
| **GROUP I** | | | | |
| 4 wks. at 45°F. | 89.2 | 23.1 (acceptable) | 36.1 (acceptable) | Inferior |
| 8 wks. at 45°F. | 89.5 | 23.3 (acceptable) | 36.2 (acceptable) | Inferior |
| *16 wks. at 45°F. | 91.8 | 23.7 (acceptable) | 38.1 (good) | Acceptable |
| 4 wks. at 60°F. | 89.5 | 23.1 (acceptable) | 36.4 (acceptable) | Inferior |
| 8 wks. at 60°F. | 89.6 | 23.4 (acceptable) | 36.2 (acceptable) | Acceptable |
| *16 wks. at 60°F. | 91.4 | 23.5 (acceptable) | 37.9 (good) | Good |
| 4 wks. at 70°F. | 89.1 | 23.3 (acceptable) | 35.8 (inferior) | Acceptable |
| 8 wks. at 70°F. | 89.3 | 23.4 (acceptable) | 35.9 (inferior) | Acceptable |
| *16 wks. at 70°F. | 90.8 | 23.5 (acceptable) | 37.3 (good) | Good |
| 4 wks. at 80°F. | 88.8 | 23.5 (acceptable) | 35.3 (inferior) | Acceptable |
| 8 wks. at 80°F. | 86.9 | 22.6 (inferior) | 34.3 (inferior) | Good |
| 16 wks. at 80°F. | 88.4 | 21.7 (inferior) | 36.7 (acceptable) | Excellent |
| **GROUP II** | | | | |
| *2 wks. at 45°F. plus 2 wks. at 60°F. | 89.5 | 23.1 (acceptable) | 36.4 (acceptable) | Good |
| 2 wks. at 45°F. plus 2 wks. at 70°F. | 89.5 | 23.3 (acceptable) | 36.2 (acceptable) | Acceptable |
| 2 wks. at 45°F. plus 2 wks. at 80°F. | 89.5 | 23.7 (acceptable) | 35.8 (inferior) | Acceptable |
| 2 wks. at 45°F. plus 6 wks. at 60°F. | 89.8 | 23.6 (acceptable) | 36.2 (acceptable) | Acceptable |
| *2 wks. at 45°F. plus 6 wks. at 70°F. | 89.7 | 23.6 (acceptable) | 36.1 (acceptable) | Good |
| 2 wks. at 45°F. plus 6 wks. at 80°F. | 86.6 | 22.2 (inferior) | 34.4 (inferior) | Good |
| **GROUP III** | | | | |
| 4 wks. at 45°F. plus 4 wks. at 60°F. | 89.5 | 23.3 (acceptable) | 36.2 (acceptable) | Acceptable |
| *4 wks. at 45°F. plus 4 wks. at 70°F. | 89.6 | 23.5 (acceptable) | 36.1 (acceptable) | Acceptable |
| 4 wks. at 45°F. plus 4 wks. at 80°F. | 88.9 | 23.3 (acceptable) | 35.6 (inferior) | Acceptable |
| **GROUP IV** | | | | |
| 2 wks. at 45° plus 6 wks. at 60°F. plus 8 wks. at 45°F. | 91.1 | 23.7 (acceptable) | 37.4 (good) | Good |
| *2 wks. at 45°F. plus 6 wks. at 70°F. plus 8 wks. at 45°F. | 91.9 | 23.8 (acceptable) | 38.1 (good) | Good |
| 2 wks. at 45°F. plus 6 wks. at 80°F. plus 8 wks. at 45°F. | 90.2 | 23.4 (acceptable) | 36.8 (acceptable) | Good |
| **GROUP V** | | | | |
| 4 wks. at 45°F. plus 4 wks. at 60°F. plus 8 wks. at 45°F. | 91.0 | 23.8 (acceptable) | 37.2 (good) | Good |
| *4 wks. at 45° plus 4 wks. at 70°F. plus 8 wks. at 45°F. | 91.6 | 24.1 (good) | 37.5 (good) | Good |
| 4 wks. at 45°F. plus 4 wks. at 80°F. plus 8 wks. at 45°F. | 90.4 | 23.5 (acceptable) | 36.9 (acceptable) | Good |
| **GROUP VI** | | | | |
| *8 wks. at 60°F. plus 8 wks. at 45°F. | 92.3 | 24.0 (good) | 38.3 (good) | Good |
| 8 wks. at 70°F. plus 8 wks. at 45°F. | 90.4 | 23.4 (acceptable) | 37.0 (good) | Good |
| 8 wks. at 80°F. plus 8 wks. at 45°F. | 88.9 | 22.5 (inferior) | 36.4 (acceptable) | Excellent |

*Outstandingly desirable cheese.

The score values given in Table 6 show that the cheese ripened by the combination of 8 weeks at 60°F. and 8 weeks at 45°F. was probably the best as it had the highest total score value and was superior in body and texture. The cheese ripened for 4 weeks at 45°F. plus 4 weeks at 70°F. and 8 weeks at 45°F. was superior in flavor, and the cheese ripened at 80°F. for 16 weeks was rated best in degree of ripning. With the temperatures of 45°, 60° and 70°F., the flavor, body and total score values increased as the ripening time was prolonged. The prolonged ripening time had a greater effect upon the body score than upon the flavor score.

The additional holding period of 8 weeks at 45°F. was more effective in improving the body and texture and ripening than in improving the flavor score. After an 8 weeks storage period at 45°F. the cheese ripened at 70°F. was considered the best. Although there was little difference in the flavor and body scores of the cheese ripened at 60° and 70°F., the cheese ripened at 70°F. ripened much faster. The cheese ripened at 45°F. was superior in body score but was slow in ripening and flavor development, and the cheese held at 80°F. ripened faster but was inferior in body score. Cheese held at 80°F. for any length of time received a lower flavor, body and total score than cheese held at any other ripening temperature. Ripening observations indicate that the degree of ripening increased as the temperature increased.

In general, cheese ripened at 45°F. for the entire ripening period was lacking in flavor development, had a tough rubbery body and lacked ripeness. Cheese ripened at 60°F. was slightly lacking in flavor, had a somewhat firm body, but had desirable ripening qualities. The cheese ripened at 70°F. was full in flavor, but had a weak and slightly crumbly body defect. Cheese held at 80°F. received a lower score because it possessed unnatural flavors and had a weak, crumbly, sticky body, but was usually fully ripened.

In determining the best ripening treatment for the production of the highest quality short cure cheese, it seems that the most desirable cheese produced within a 4 weeks curing period was the cheese held 2 weeks at 45°F. and 2 weeks at 60°Fahrenheit. The cheese held 2 weeks at 45°F. and 2 weeks at 70°F. was almost equally as good except its ripening condition was less satisfactory. The most desirable cheese produced in an 8 weeks ripening period was that held 2 weeks at 45°F. and 6 weeks at 60°Fahrenheit. The cheese held 8 weeks at 60°F. was somewhat lower in score value at the end of an 8 weeks period, but after an additional 8 weeks storage period at 45°F., it developed into a higher scoring cheese. These results indicate that, by the use of the proper ripening treatment, a cheese of desirable quality can be produced for marketing within a 4 to 8 weeks period.

Table 7 shows a detailed analysis of the protein hydrolysis and the distribution of the different fractions of nitrogen at various intervals during ripening.

**Table 7. The effect of various ripening treatments upon protein hydrolysis and the nitrogen distribution**

| Ripening Treatment | Total Nitrogen | Water Soluble Nitrogen | Water Soluble N not precipitated by | | |
|---|---|---|---|---|---|
| | | | Trichloracetic acid | Tannic acid-salt | Phosphotungstic acid |
| | per cent | per cent | per cent | per cent | per cent |
| 1 day old | 3.3 | 4.9 | 3.8 | 6.0 | 1.0 |
| **GROUP I** | | | | | |
| 2 wks. at 45°F. | 3.5 | 12.4 | 9.3 | 5.3 | 1.7 |
| 4 wks. at 45°F. | 3.6 | 16.0 | 12.0 | 4.0 | 2.6 |
| 8 wks. at 45°F. | 3.6 | 18.6 | 13.4 | 5.1 | 3.2 |
| *16 wks. at 45°F. | 3.6 | 25.5 | 20.2 | 8.0 | 6.0 |
| 2 wks. at 60°F. | 3.5 | 15.2 | 11.6 | 6.3 | 2.3 |
| 4 wks. at 60°F. | 3.6 | 20.5 | 15.1 | 5.3 | 4.1 |
| 8 wks. at 60°F. | 3.6 | 26.2 | 21.0 | 9.1 | 6.4 |
| *16 wks. at 60°F. | 3.6 | 39.6 | 36.3 | 21.0 | 17.1 |
| 2 wks. at 70°F. | 3.6 | 17.1 | 14.1 | 7.1 | 3.2 |
| 4 wks. at 70°F. | 3.6 | 23.6 | 19.3 | 7.9 | 5.4 |
| 8 wks. at 70°F. | 3.6 | 30.5 | 26.0 | 12.4 | 9.3 |
| *16 wks. at 70°F. | 3.6 | 41.9 | 37.7 | 24.3 | 21.3 |
| 2 wks. at 80°F. | 3.6 | 19.6 | 16.4 | 7.8 | 4.1 |
| 4 wks. at 80°F. | 3.6 | 26.8 | 22.8 | 12.3 | 7.6 |
| 8 wks. at 80°F. | 3.6 | 33.1 | 29.0 | 16.5 | 12.6 |
| 16 wks. at 80°F. | 3.7 | 44.1 | 41.4 | 29.9 | 24.9 |
| **GROUP II** | | | | | |
| *2 wks. at 45°F. plus 2 wks. at 60°F. | 3.6 | 18.0 | 13.9 | 5.0 | 3.3 |
| 2 wks. at 45°F. plus 2 wks. at 70°F. | 3.6 | 21.2 | 17.4 | 6.5 | 4.3 |
| 2 wks. at 45°F. plus 2 wks. at 80°F. | 3.6 | 24.9 | 19.3 | 7.4 | 8.0 |
| 2 wks. at 45°F. plus 6 wks. at 60°F. | 3.6 | 26.2 | 20.4 | 8.4 | 6.2 |
| *2 wks. at 45°F. plus 6 wks. at 70°F. | 3.6 | 29.2 | 24.2 | 10.4 | 7.8 |
| 2 wks. at 45°F. plus 6 wks. at 80°F. | 3.6 | 33.9 | 30.3 | 14.9 | 11.8 |
| **GROUP III** | | | | | |
| 4 wks. at 45°F. plus 4 wks. at 60°F. | 3.5 | 25.4 | 19.1 | 8.6 | 5.5 |
| *4 wks. at 45°F. plus 4 wks. at 70°F. | 3.6 | 27.0 | 21.2 | 8.4 | 6.4 |
| 4 wks. at 45°F. plus 4 wks. at 80°F. | 3.6 | 30.2 | 24.5 | 10.0 | 8.2 |
| **GROUP IV** | | | | | |
| 2 wks. at 45°F. plus 6 wks. at 60°F. plus 8 wks. at 45°F. | 3.5 | 32.2 | 26.9 | 12.3 | 9.2 |
| *2 wks. at 45°F plus 6 wks. at 70°F. plus 8 wks. at 45°F. | 3.6 | 33.9 | 29.9 | 14.9 | 11.4 |
| 2 wks. at 45°F. plus 6 wks. at 80°F. plus 8 wks. at 45°F. | 3.6 | 35.9 | 32.8 | 17.5 | 13.1 |
| **GROUP V** | | | | | |
| 4 wks. at 45°F. plus 4 wks. at 60°F. plus 8 wks. at 45°F. | 3.6 | 30.8 | 25.6 | 11.5 | 8.4 |
| *4 wks. at 45°F. plus 4 wks. at 70°F. plus 8 wks. at 45°F. | 3.6 | 32.6 | 27.3 | 12.1 | 9.4 |
| 4 wks. at 45°F. plus 4 wks. at 80°F. plus 8 wks. at 45°F. | 3.6 | 36.8 | 32.3 | 15.6 | 11.9 |
| **GROUP VI** | | | | | |
| *8 wks. at 60°F. plus 8 wks. at 45°F. | 3.6 | 30.5 | 26.4 | 12.9 | 9.8 |
| 8 wks. at 70°F. plus 8 wks. at 45°F. | 3.6 | 35.6 | 31.5 | 17.0 | 12.8 |
| 8 wks. at 80°F. plus 8 wks. at 45°F. | 3.6 | 36.0 | 33.7 | 19.8 | 15.6 |

*Outstandingly desirable cheese.

Table 7 shows that the rate of production of water soluble nitrogen and the water soluble nitrogen not precipitated by trichloracetic acid was very similar. The rate was greatest in the first part of the period for all lots. In each of those lots which was held at 50°, 60°, 70° and 80°F. for the entire 16 weeks period, the rate of production was quite uniform after the fourth week. The difference in amount of water soluble nitrogen and the trichloracetic acid fraction produced between the 45° and 60°F. ripening temperatures was much greater than the difference between the tem-

peratures of 60° and 70°F. or between 70° and 80°Fahrenheit. The amount of water soluble nitrogen present at the end of the fourth week of ripening was 16.0, 20.5, 23.6 and 26.8 per cent, and the amount of water soluble nitrogen not precipitated by trichloracetic acid at the end of the ripening period was 12.0, 15.1, 19.3 and 22.8 per cent at ripening temperatures of 45°, 60°, 70° and 80°F., respectively.

The tannic acid-salt fraction and the phosphotungstic acid fraction did not show the rapid rate of increase in the early part of the ripening period that was shown in the water soluble nitrogen and the trichloracetic acid fraction. The tannic acid-salt fraction was higher in every case than the phosphotungstic acid fraction. The percentage of the tannic acid-salt fraction at the end of the fourth week of ripening was 4.0, 5.3, 7.9 and 12.3, and the percentage of the phosphotungstic acid fraction was 2.6, 4.1, 5.4 and 7.6 at the ripening temperatures of 45°, 60°, 70° and 80°F., respectively.

The rate of hydrolysis of cheese held at 45°F. was more uniform throughout the 16 weeks ripening period; whereas, that of cheese held at the 60°, 70° and 80°F. showed uniform hydrolysis for 4 weeks after which there was considerable increase in the rate of protein decomposition. The rate and amount of hydrolysis decreased as the ripening temperature decreased; it was greatest at 80°F., followed in order by 70°, 60° and 45°Fahrenheit. The rate of hydrolysis increased when the cheese was moved from 45°F. to any of the higher temperatures. The increase being greater at the higher temperatures. Protein hydrolysis was checked by moving the cheese from the higher temperatures to the 45°F. ripening temperature. No specific relationship could be established between the various nitrogen fractions and the quality of the cheese except that the score value increased as the amount of proteolysis increased. Excessive proteolysis, however, resulted in lower score values.

### Effect of the Amount of Rennet Extract Upon Quality and Rate of Ripening at Various Temperatures

The effect of 2, 4 and 8 ounces of rennet extract per 1000 pounds of milk upon the quality of cheese ripened at various temperatures for a 12 week period is given in Table 8.

The results indicate that the cheese made using 8 ounces of rennet per 1000 pounds of milk was superior at all ripening temperatures in flavor and condition of ripening. The cheese made using 4 ounces of rennet per 1000 pounds of milk was superior in body and texture score. The use of only 2 ounces of rennet per 1000 pounds of milk produced a slow ripening cheese at all of the temperatures studied. The results suggest that the amount of rennet used is an important factor in producing a short cure cheese. The use of 8 ounces of rennet per 1000 pounds of milk produced a cheese with superior flavor and ripening qualities, but the body of this cheese was weak and sticky. Therefore, the use of 8 ounces of rennet per 1000 pounds of milk cannot be recommended to give better results than 4 ounces of rennet per 1000 pounds of milk in the production of a short cure cheese.

**Table 8. The effect of the amount of rennet extract upon the quality of cheese ripened at various temperatures for 12 weeks**

| Ripening temperatures degrees F. | Ounces of rennet extract per 1000 lbs. milk | Flavor score | Body and texture score | Degree of ripeness |
|---|---|---|---|---|
| 45 | 2 | 23.5 (acceptable) | 35.7 (inferior) | Inferior |
| | 4 | 23.5 (acceptable) | 37.2 (good) | Inferior |
| | 8 | 24.0 (good) | 36.7 (acceptable) | Acceptable |
| 60 | 2 | 23.5 (acceptable) | 35.7 (inferior) | Inferior |
| | 4 | 23.7 (acceptable) | 37.0 (good) | Acceptable |
| | 8 | 24.2 (good) | 36.7 (acceptable) | Good |
| 70 | 2 | 23.7 (acceptable) | 35.5 (inferior) | Inferior |
| | 4 | 24.0 (good) | 37.5 (good) | Good |
| | 8 | 24.7 (good) | 36.5 (acceptable) | Good |
| 80 | 2 | 23.7 (acceptable) | 34.2 (inferior) | Inferior |
| | 4 | 24.2 (good) | 36.9 (acceptable) | Acceptable |
| | 8 | 24.7 (good) | 36.2 (acceptable) | Good |

**Table 9. Effect of the amount of rennet extract upon protein hydrolysis of cheese ripened at various temperatures for 12 weeks**

| Ripening temperatures | Rennet extract per 1000 lbs. of milk | Water soluble nitrogen | Water soluble N precipitated by | | Moisture |
|---|---|---|---|---|---|
| | | | Trichloracetic acid | Phosphotungstic acid | |
| degrees F. | ounces | per cent | per cent | per cent | per cent |
| 45 | 2 | 10.4 | 8.4 | 3.9 | 35.8 |
| | 4 | 13.7 | 8.4 | 3.2 | 34.7 |
| | 8 | 16.3 | 9.7 | 2.7 | 34.4 |
| 60 | 2 | 17.9 | 15.3 | 5.1 | 34.5 |
| | 4 | 20.8 | 12.8 | 6.4 | 33.3 |
| | 8 | 22.2 | 17.2 | 5.5 | 33.0 |
| 70 | 2 | 17.9 | 16.5 | 6.7 | 32.7 |
| | 4 | 22.4 | 16.1 | 8.1 | 31.2 |
| | 8 | 26.5 | 19.5 | 7.7 | 31.3 |
| 80 | 2 | 19.1 | 17.2 | 7.5 | 30.3 |
| | 4 | 25.7 | 18.8 | 8.4 | 31.3 |
| | 8 | 26.3 | 20.8 | 8.2 | 32.4 |

Table 10. Comparison of the quality of cheese made by the stirred curd and cheddar methods

| Ripening temperature | Ripening period | Flavor score | | Body score | | Degree of ripeness | |
|---|---|---|---|---|---|---|---|
| degrees F. | weeks | Stirred curd | Cheddar | Stirred curd | Cheddar | Stirred curd | Cheddar |
| 45 | 8 | 23.20 (acceptable) | 23.20 (acceptable) | 36.40 (acceptable) | 34.00 (inferior) | Inferior | Acceptable |
| | 16 | 23.50 (acceptable) | 23.70 (acceptable) | 38.40 (good) | 38.40 (good) | Good | Good |
| 60 | 8 | 23.50 (acceptable) | 23.50 (acceptable) | 36.40 (acceptable) | 34.40 (inferior) | Acceptable | Acceptable |
| | 16 | 23.70 (acceptable) | 24.00 (good) | 35.40 (inferior) | 38.40 (good) | Good | Good |
| 70 | 8 | 24.00 (good) | 23.90 (acceptable) | 36.40 (acceptable) | 34.00 (inferior) | Good | Good |
| | 16 | 25.00 (excellent) | 25.00 (excellent) | 37.00 (good) | 38.00 (good) | Excellent | Excellent |
| 80 | 8 | 25.00 (excellent) | 24.50 (good) | 32.00 (inferior) | 33.40 (inferior) | Good | Good |
| | 16 | 22.70 (inferor) | 23.50 (good) | 34.00 (inferior) | 37.00 (good) | Excellent | Excellent |

In order to determine the effect of the amount of rennet extract upon protein hydrolysis, a detailed chemical analysis was made of the various nitrogen soluble fractions of cheese manufactured with different amounts of rennet and ripened at various temperatures for a period of 12 weeks. The results are shown in Table 9.

The amount of protein hydrolysis increased with additional amounts of rennet extract and also with the increase in temperature. From the figures in Table 9, calculations can be made to show that by using 8 ounces instead of 2 ounces of rennet extract per 1000 pounds of milk the water soluble nitrogen was increased 57 per cent in cheese ripened at 45°Fahrenheit. At temperatures of 60°, 70° and 80°F., this increase was 24, 48 and 38 per cent, respectively.

In those lots containing 4 ounces of rennet per 1000 pounds of milk, the cheese ripened at 60°F. showed 51 per cent more water soluble nitrogen than cheese ripened at 45°F., but the increase of the water soluble nitrogen of the cheese ripened at 70°F. was only 10 per cent greater than that at 60F., and the increase in the cheese ripened at 80°F. was only 7 per cent above that ripened at 70°Fahrenheit. These percentages indicate that protein hydrolysis was affected to the greatest extent between the temperatures of 45° and 60°F., and that additional amounts of rennet extract brought about more rapid protein hydrolysis at all temperatures studied.

**Effect of Stirred Curd and Cheddar Methods Upon the Rate of Ripening**

The average flavor and body scores and ripening observations of cheese made by the stirred curd and cheddar methods after 8 and 16 weeks of ripening are recorded in Table 10.

It can be seen that the stirred curd cheese was better than the cheddar cheese at the end of an 8 weeks period. The highest flavor score was given to the stirred curd cheese ripened at 80°Fahrenheit. The stirred curd cheese also was usually superior in body score at the end of the 8 weeks curing period. However, after 16 weeks of ripening, the cheese made by the cheddar method had higher flavor and body scores. There was an indication that the stirred curd cheese ripened faster but did not reach as high a maximum score over a long curing period.

A more detailed analysis of the ripening properties of the cheese manufactured by the two methods is presented in Table 11.

In summarizing the results presented in Table 11, it can be seen that cheese made by the cheddar method retained a greater amount of water during ripening and had a somewhat firmer body than the stirred curd type cheese except at the 80°F. ripening temperature.

The stirred curd cheese was highest in protein derived products at nearly every interval during the ripening process. This indicates that protein hydrolysis was more rapid in the stirred curd cheese, and that this method might be of value for use in the production of a rapid curing cheese under special conditions.

Table 11. A comparison of the ripening properties of stirred curd and cheddar cheese at different temperatures

| Ripening temperatures | Ripening period | pH | | Moisture per cent | | Hardness grams | | Water soluble nitrogen per cent | | Water soluble N not precipitated by: Trichloracetic acid per cent | | Water soluble N not precipitated by: Phosphotungstic acid per cent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| degrees F. | weeks | Stirred curd | Cheddar | Stirred curd | Cheddar | Stirred curd | Cheddar | Stirred curd | Cheddar | Stirred curd | Cheddar | Stirred curd | Cheddar |
| 45 | 8 | 5.20 | 5.03 | 35.5 | 37.6 | 591 | 620 | 22.0 | 21.3 | 15.4 | 15.9 | 3.6 | 3.2 |
| | 16 | 5.67 | 5.38 | 34.6 | 36.8 | 509 | 539 | 30.2 | 27.2 | 23.2 | 22.4 | 3.6 | 6.9 |
| 60 | 8 | 5.20 | 5.02 | 36.3 | 37.9 | 606 | 644 | 30.7 | 26.2 | 24.0 | 22.8 | 7.5 | 7.0 |
| | 16 | 5.46 | 5.41 | 34.1 | 36.2 | 718 | 712 | 39.2 | 34.8 | 36.2 | 35.3 | 15.5 | 14.9 |
| 70 | 8 | 5.27 | 5.10 | 35.0 | 37.0 | 630 | 663 | 36.1 | 32.5 | 30.3 | 27.9 | 12.2 | 9.1 |
| | 16 | 5.63 | 5.55 | 33.6 | 35.9 | 658 | 676 | 44.4 | 42.0 | 39.1 | 37.9 | 21.5 | 19.6 |
| 80 | 8 | 5.37 | 5.20 | 34.3 | 36.1 | 912 | 753 | 36.6 | 37.6 | 32.4 | 31.3 | 14.6 | 13.2 |
| | 16 | 5.27 | 5.72 | 34.5 | 35.9 | 825 | 738 | 44.3 | 47.1 | 40.3 | 42.5 | 23.6 | 24.7 |

### The Effect of High Acidity and of Washing the Curd Upon the Quality of Cheese

The effect of acidity and various curd treatments upon the quality of cheese at the end of a 4 weeks ripening period is shown in Table 12.

The control, washed curd, and pasteurized curd lots of the high acid cheese (pH 5.0) were poorer in flavor than their paired lots of the normal acid cheese (pH 5.5). The control lots of the high acid cheese decreased in flavor score as the ripening temperature increased. The washed curd lots received the best flavor scores of the high acid cheese. The control lots were better in flavor than the pasteurized curd lots when ripened at 45° and 60°F., but the reverse was true at the temperatures of 70° and 80° Fahrenheit. In the normal acid cheese, the washed curd lots were best in flavor.

According to the average body score, the control and washed curd lots of high acid cheese were better than their paired lots of normal acid cheese at the temperatures of 45° and 60°F., but at temperatures of 70° and 80°F. the reverse was true. The pasteurized curd lots of the high acidity cheese were better than the corresponding lots of normal acid cheese. In both the high acid and normal acid cheese the washed curd lots were superior in body score. The curd treatments studied appear to be of little value in increasing the quality of cheese during a four weeks ripening period.

The influence of different curd treatments during the manufacturing process upon the analysis and nitrogen distribution of cheese after a 4 weeks ripening period at various temperatures is shown in Table 13.

The amount of hydrolysis was greater in the high acid lots of cheese than in the normal lots of cheese. Pasteurization of the curd retarded protein hydrolysis at the lower temperatures, but this effect was not as pronounced at the higher ripening temperatures. The washed curd cheese in both the high and normal groups of cheese had somewhat greater protein hydrolysis.

## DISCUSSION

The results of the preliminary investigation indicated that the use of large amounts of rennet and the washed curd treatment proved most effective in producing a cheese with a superior body. The temperature at which the cheese was ripened was of ultimate importance in influencing the rate of flavor development and the score of the cheese. The amount of rennet used was an important factor in the production of a short cure cheese, as additional amounts of rennet extract, up to as much as eight ounces per 1000 pounds of milk produced more rapid ripening and increased the score value of the cheese at ripening temperatures as high as 70°Fahrenheit. Cheese manufactured by the stirred curd method ripened more rapidly than did the cheese manufactured by the regular cheddar method. The stirred curd method may have some value in the manufacture of a rapid cure cheese but cheese made by this method did not reach as high a maximum score as did cheese made by the cheddar method. There was no advantage obtained by developing a higher acidity during the manufacturing process; however, washing the curd improved the quality of the cheese and increased the rate of ripening. Perhaps the desirable conditions secured by the use of the stirred curd method and by washing the curd were the results of a reduced acidity of the cheese at the time of pressing and in some cases a somewhat higher moisture content of the cheese. Both of these factors encourage increased bacterial action and more rapid ripening.

Table 12. Effect of high acidity and various curd treatments upon the quality of cheese (4 weeks ripening)

| Ripening temperatures | Flavor score | | | Body score | | | Degree of Ripeness | | |
|---|---|---|---|---|---|---|---|---|---|
| degrees F. | Control | Washed curd | Pasteurized curd | Control | Washed curd | Pasteurized curd | Control | Washed curd | Pasteurized curd |
| | | | | High Acidity (pH 5.0) | | | | | |
| 45 | 23.30 (acceptable) | 23.20 (acceptable) | 22.90 (inferior) | 35.40 (inferior) | 35.60 (inferior) | 35.20 (inferior) | Acceptable | Acceptable | Acceptable |
| 60 | 23.00 (acceptable) | 23.50 (acceptable) | 22.80 (inferior) | 35.00 (inferior) | 35.80 (inferior) | 34.80 (inferior) | Acceptable | Acceptable | Acceptable |
| 70 | 22.80 (inferior) | 23.60 (acceptable) | 23.20 (acceptable) | 34.60 (inferior) | 35.20 (inferior) | 35.00 (inferior) | Acceptable | Acceptable | Inferior |
| 80 | 22.70 (inferior) | 22.60 (inferior) | 22.80 (inferior) | 34.00 (inferior) | 34.40 (inferior) | 34.80 inferior | Acceptable | Acceptable | Acceptable |
| | | | | Normal Acidity (pH 5.5) | | | | | |
| 45 | 23.50 (acceptable) | 23.70 (acceptable) | 23.30 (acceptable) | 34.40 (inferior) | 35.00 (inferior) | 33.80 (inferior) | Inferior | Inferior | Inferior |
| 60 | 23.40 (acceptable) | 23.60 (acceptable) | 23.50 (acceptable) | 35.00 (inferior) | 35.60 (inferior) | 33.80 (inferior) | Inferior | Acceptable | Inferior |
| 70 | 23.50 (acceptable) | 23.70 (acceptable) | 23.10 (acceptable) | 35.40 (inferior) | 35.80 (inferior) | 33.60 (inferior) | Inferior | Acceptable | Inferior |
| 80 | 23.50 (acceptable) | 23.70 (acceptable) | 23.20 (acceptable) | 35.00 (inferior) | 35.00 (inferior) | 34.00 (inferior) | Inferior | Acceptable | Inferior |

**Table 13. Effect of acidity and different curd treatments upon the ripening properties of cheese ripened at various temperatures**

| Ripening temperatures | pH | | | | Moisture | | | | Water soluble nitrogen | | | | Water soluble not precipitated by | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | per cent | | | | per cent | | | | Trichloracetic acid per cent | | | | Phosphotungstic acid per cent | | | |
| degrees F. | 45 | 60 | 70 | 80 | 45 | 60 | 70 | 80 | 45 | 60 | 70 | 80 | 45 | 60 | 70 | 80 | 45 | 60 | 70 | 80 |
| High Acidity (pH 5.0) | | | | | | | | | | | | | | | | | | | | |
| Control | 5.1 | 5.0 | 4.9 | 5.0 | 38.4 | 36.4 | 34.0 | 34.0 | 16.7 | 19.9 | 19.8 | 21.5 | 16.4 | 17.3 | 19.0 | 21.6 | 4.5 | 5.6 | 6.6 | 7.7 |
| Washed curd | 5.1 | 5.0 | 5.2 | 5.1 | 41.0 | 39.2 | 36.2 | 34.0 | 21.9 | 19.0 | 22.7 | 23.8 | 11.6 | 19.1 | 21.7 | 24.6 | 2.0 | 5.7 | 5.7 | 9.5 |
| Pasteurized curd | 5.4 | 5.3 | 5.3 | 5.2 | 43.0 | 41.0 | 41.1 | 40.5 | 18.0 | 20.2 | 24.8 | 26.2 | 9.6 | — | 14.8 | 23.3 | 2.4 | — | 2.5 | 8.1 |
| Normal Acidity (pH 5.5) | | | | | | | | | | | | | | | | | | | | |
| Control | 5.3 | 5.3 | 5.2 | 5.2 | 34.4 | 34.7 | 33.5 | 33.5 | 11.9 | 16.1 | 19.5 | 21.2 | 10.3 | 17.5 | 19.0 | 21.2 | 3.8 | 4.9 | 7.5 | 8.0 |
| Washed curd | 5.4 | 5.4 | 5.4 | 5.4 | 37.7 | 36.4 | 35.5 | 34.4 | 13.9 | 17.0 | 19.1 | 18.1 | 11.2 | 15.4 | 16.1 | 21.5 | 3.4 | 4.7 | 4.9 | 8.7 |
| Pasteurized curd | 5.7 | 5.7 | 5.6 | 5.7 | 35.7 | 35.5 | 34.3 | 34.7 | 7.1 | 10.7 | 12.4 | 13.2 | 5.8 | 9.0 | — | 12.1 | .8 | 1.7 | — | 2.6 |

The ripening temperature was increased to a maximum of 70°F. with desirable results. The rate of flavor development was greatly increased by raising the ripening temperature; however, a prolonged ripening time was necessary to secure a high body score. The rate of ripening had a direct effect upon the quality of the cheese. Ripening time was greatly decreased at higher temperatures and in many cases high rates of proteolysis resulted in cheese of corresponding lower score values. When cheese was ripened for 4, 8 and 16 weeks periods, the highest scoring cheese for each period was that ripened at 60°F. and 70°F. plus an initial storage period at 45°Fahrenheit. Cheese ripened at 80°F. was inferior in most cases. In the production of a short cure cheese a ripening period at a higher temperature for flavor was desirable, and an additional storage period was beneficial to body development. Of all the factors studied, the temperature of ripening and the amount of rennet used seemed most important in the production of a short cure cheese.

The results of this investigation indicate that a high score short cure cheese can be produced for marketing within a four weeks period by using 4 ounces of rennet per 1000 pounds of milk and by holding the cheese at 60°F. during a portion of the ripening period. As much as 8 ounces of rennet per 1000 pounds of milk gave desirable results except at temperatures as high as 80°Fahrenheit. The best cheese produced within a four weeks period was ripened for two weeks at 45°F. and two weeks at 60°Fahrenheit. The best cheese produced within an eight weeks period was ripened two weeks at 45°F. and six weeks at 60°Fahrnheit.

## CONCLUSIONS

1. A detailed study of the effect of ripening temperature upon the quality of short cure cheese showed that the temperature of 60°F. gave the most desirable results, and that temperatures as high as 70°F. could be used with satisfactory results.
2. The rate of proteolysis was greatly increased by ripening temperature.
3. Proteolysis was checked by moving cheese from higher temperatures to a storage temperature of 45°Fahrenheit.
4. When 2, 4 and 8 ounces of rennet extract were used per 1000 pounds of milk, it was found that the 4 ounce quantity gave the most desirable results and that as much as 8 ounces of rennet per 1000 pounds of milk could be used with satisfactory results.
5. When 2, 4 and 8 ounces of rennet extract were used per 1000 pounds of milk, the rate of proteolysis increased with each additional increment of rennet at all ripening temperatures.
6. There was an indication that stirred curd cheese ripened faster but did not reach as high a maximum score as did cheese made by the cheddar method.
7. There was no advantage obtained in rate of ripening and quality of cheese by developing a higher acidity during the cheese manufacturing process.
8. The results of this investigation are significant in that they indicate that a high score short cure cheese can be produced for marketing within a four weeks period, by using 4 ounces of rennet extract per 1000 pounds of milk and by holding the cheese at a temperature of 60° to 70°F. during a portion of the ripening period.

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